BIO120H:
Adaptation & Biodiversity

Talent
Education

Week 0-1

Fall 2021

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SYLLABUS

BIO120H1F – Adaptation & Biodiversity
Department of Ecology and Evolutionary Biology, University of Toronto

Course Syllabus – Fall 2021

The BIO120H Team

Lecturers: **Prof. Megan Frederickson** (Lectures 1-12) **Prof. John Stinchcombe** (Lectures 13-24)	**Jill Wheeler**, Course and Laboratory Coordinator **Laura Heslin Piper**, Course Administrator **Veronica Chong**, Course Technician **Jessica Leivesley** and **Bianca Sacchi**, Lecture TAs + many **Laboratory Teaching Assistants** **Dom Fenech** and **Dongling Zhao**, Laboratory Technicians

BIO120H Office – bio120@utoronto.ca

- Please direct all course enquiries to the BIO120 office; the office will re-direct enquiries as appropriate.
- Email: **bio120@utoronto.ca.**
- Phone: 416-978-7588 (*when contacting by phone, leave a voicemail with a phone number where we can reach you*)
- Please include your full name and student number when emailing the BIO120 Office

Course Description

Principles and concepts of evolution and ecology related to origins of adaptation and biodiversity. Mechanisms and processes driving biological diversification illustrated from various perspectives using empirical and theoretical approaches. Topics include: genetic diversity; natural selection; speciation; physiological, population and community ecology; maintenance of species diversity; global environmental change; conservation, species extinction, and invasion biology. Prerequisite: Grade 12 Biology or equivalent. Exclusion: BIO150Y1Y.

Course Objectives

1. A goal of this course is to provide you with a solid foundation in evolutionary and ecological principles and concepts – as related to the origins of adaptation and biodiversity – so that you can make informed decisions on pressing societal issues, such as population growth, global environmental change, and the conservation of biodiversity, and be prepared for advanced study in the biological sciences.
2. Darwinian evolution is the unifying concept in biology and explains biodiversity on earth and why species differ. You will learn that the traits of organisms are the product of a complex interplay between natural selection, genetic variation, and evolutionary history.
3. You will learn that adaptive evolution is a process that results from selection pressures imposed by the physical and biotic environment on individuals within populations. The ecological challenges of capturing resources for growth, successful reproduction, and avoiding enemies largely determine the ways organisms function.
4. Required readings for Prof. Frederickson's lectures will extend and reinforce lecture material on how natural systems work and how diverse organisms respond to the challenges of the natural world. From reading *Why Evolution is True* for Prof. Stinchcombe's lectures, you will learn how various independent lines of evidence demonstrate the fact of evolution and give insight into its mechanisms, particularly adaptation by natural selection.
5. In the laboratories you will learn to make observations, devise hypotheses, and conduct experiments in ecology and evolutionary biology, including critically evaluating and communicating (both orally and in writing) hypotheses and experimental designs.

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Online Course Delivery

This course will be delivered online, including all lectures, labs, and assessments:

- Labs will be run as live sessions at scheduled times and will not be recorded.
- Lecture slides and videos will be posted online every Monday.

To complete the course, you will need to have access to a computer with administrator privileges and a reliable internet connection (**note that mobile devices are not guaranteed to work for all aspects of the course**). High speed broadband internet access is recommended for an optimal learning experience. You will need a web browser and word processing software to complete the course, and you will also need to download ImageJ and SimUText software to complete the labs (details and download links will be posted on Quercus). **Note: We are running the course from Toronto so all times refer to the Toronto time zone (Eastern Daylight Time UTC-4 until November 7th, Eastern Standard Time UTC-5 from November 8th to end of term)**

Course Required Materials (*#2 is available from the U of T Bookstore*)

1. ***BIO120 Laboratory Manual Fall 2021***
   The lab manual chapters will be posted as PDFs on Quercus. You cannot use other lab manual editions (e.g., if you took BIO120 in Fall 2020, you cannot re-use your lab manual).
2. ***Why Evolution is True*** by Jerry Coyne (2009 or later, paperback edition OR eBook edition, Penguin).
3. ***SimUText Learning Software***
   We have assigned two online learning modules from SimUText – one module to complement a lecture and one module to complement a lab. You will need to pay for and download the SimUText learning software onto your computer. Detailed information will be posted on Quercus.
4. Additional readings (such as journal articles) will be posted on Quercus.

Course Site on Quercus

The BIO120 course website will be available on Quercus (q.utoronto.ca) for the Fall. Quercus is the learning management system for U of T. For information on using Quercus, please see the "Help" button on Quercus, or the links we post on the course site. All course materials will be posted on Quercus, and all course activities will take place online and are accessed through the Quercus course page. Only students who are enrolled in BIO120 on ACORN have access to this site (within 24-48 hours after enrolling). **It is mandatory that you check the announcements at least once a week, and we strongly recommend checking Quercus daily. We strongly recommend turning on announcements in your Notifications setting so that you receive them as emails.**

Lectures

- Starting September 13, we will post two (2) lectures every week on Mondays to Quercus
- The lecture schedule is available on page *vi* and on Quercus.
- You can find the following materials under the "Lectures Module" on Quercus:
  - **Videos:** There will be 1-3 videos per lecture
  - **Lecture slides**: These are the slides shown in the videos (available as PDFs)
  - **Required readings:** These are the pages/articles that you are required to read before each lecture

Copyright

Lectures and course materials prepared by the instructors are considered by the University to be an instructor's intellectual property covered by the *Copyright Act*, RSC 1985, c C-42. Course materials such as the lab manual, PowerPoint slides and lecture recordings are made available to you for your own study purposes. These materials cannot be shared outside of the class or "published" in any way. Posting the lab manual, lecture recordings or slides to other websites without the express permission of the instructor will constitute copyright infringement.

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Lecture Tutorials

This is your chance to ask the professor questions about lecture content. These are held online through Zoom twice a week: **Tuesdays from 5:10-6:00 pm and Wednesdays at 10:10-11:00 am.** Attendance is optional. You can ask questions via the chat function. The lecture tutorial's access link will be posted on Quercus.

Optional BIO120 Live

We will also offer "**BIO120 Live" on Mondays at 2:10-3:00 pm online** in alternate weeks. These sessions provide the opportunity for students to further engage with the course by learning more about ecology and evolution (e.g., meet the insects, etc). They are optional. Each BIO120 Live event will be announced on Quercus.

Reading Quizzes

- Quizzes will be available on Quercus to help you assess your understanding of the required readings, and to motivate you to do the readings before each lecture.
- Detailed information on the reading quizzes is available on Quercus under "Reading Quizzes".

Laboratories (*also read the BIO120 Laboratory Manual for detailed information, available on Quercus*)

- Check the "Grades" link on Quercus after 5:00 pm on Monday, Sept. 13; there will be a column that shows a code, which corresponds to the week, day, time, and TA of your lab.
- Labs are held in alternate weeks (bi-weekly); see the detailed lab schedule on page *iv* in your BIO120 Laboratory Manual. Labs are held online and are not recorded. Attendance is mandatory.
- **Week 1 (P**01) labs begin the week of Sept. 20; Week 2 (P**02) labs begin the week of Sept. 27**
- Labs are up to 2.5 hours in length. Tues., Wed., and Thur. afternoon labs begin at 1:30 pm; Thur. evening labs begin at 6:10 pm; and Fri. morning labs begin at 11:10 am.
- **Preparation for Lab 1**: Read the Introduction, Chapters 1 and 6, and Appendix B in the BIO120 Laboratory Manual Fall 2021. Answer the questions on page 1-14 of the lab manual before your lab.
- Beginning on Sept. 14, if you are **not** enrolled in a practical section on ACORN, please contact the BIO120 Office at bio120@utoronto.ca. You must be enrolled in a practical section to complete the course.
- Procedures for requesting a temporary lab change (for example, due to illness) are discussed in the "Important Policies and Procedures" section on page *v* of this syllabus.

Where to ask questions about course content

- As it is impractical for Lecturers to offer office hours for a course of this size, any questions on **lecture** content can be (1) asked during the weekly Lecture Tutorials conducted by the professors (see page *iii*), or (2) posted under "Discussions" on Quercus, which is monitored by the BIO120 Lecture TAs (Teaching Assistants who attend lectures).
- Any questions on **laboratory** content can be (1) directed to your TA during regular lab time, (2) asked during the Course Coordinator's office hours online, or (3) posted on the BIO120 Discussions page on Quercus.
- The **Discussions page** on Quercus has been created for students to post their questions regarding course material. It is expected that students will respond to their classmates' questions. Course staff will respond to posts where appropriate (and within 48 hours, weekdays only).

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Support Services

If any student has concerns about the course or is having a hard time in general, we want to encourage you to contact us (bio120@utoronto.ca). Below are additional services available to U of T students:

- The Academic Success Centre provides workshops and one-on-one learning strategy sessions for students who are looking to improve their study habits.
- If you feel there is a medical/accessibility concern impacting your ability to study or complete academic work to the best of your ability, you may find it helpful to contact Accessibility Services. They are responsible for arranging ongoing accommodations for students where appropriate.
- Health & Wellness through Student Life offers mental health care.
- If you are having a hard time overall and you are not sure what kind of support would help, you may find it helpful to contact your College Registrar's office. The Registrars are a central resource at U of T, and they have excellent advisors who can give degree-planning advice and connect you to other resources on campus.

Evaluation

Lecture material, including required readings	67%
Lab material, including required readings	33%
You must obtain a minimum of 50% on the laboratory material (see page *v*) to pass the course.	

Evaluation Details:

Test 1: Wednesday, October 13 at 6:30 p.m. • Content: Multiple-choice and short-answer questions covering Lectures 1 to 8 (Prof. Frederickson), including associated required readings and *Population Growth* SimUText exercise. (Lab material will not be evaluated on Test 1.)	21%
Test 2: Wednesday, November 17 at 6:30 p.m. • Content: Multiple-choice and short-answer questions covering Lectures 9 to 12 (Prof. Frederickson) and Lectures 13 to 16 (Prof. Stinchcombe) and Lab Chapters 1 to 3, including associated lecture and lab required readings.	22%
Test 3: (during December 10-21 Final Assessment period, exact date TBA) • Content: Multiple-choice and short-answer questions covering Lectures 17 to 24 (Prof. Stinchcombe) and Lab Chapters 4 and 5 and Appendix A and *Sickle Cell Alleles* SimUText exercise, including associated lecture and lab required readings.	23%
Laboratory quizzes and assignments • Lab Quizzes (5%), Lab 5 Assignment (1%), *Sickle Cell Alleles* SimUText exercise (2%) and "Writing a Scientific Proposal" assignments (19%). • See page *v* in the BIO120 Laboratory Manual for detailed information.	27%
Reading Quizzes • Quizzes on required readings for the lecture content (e.g., *Why Evolution is True* and other required readings) (4%) • *Population Growth* SimUText exercise (2%)	6%
Course and Teaching Assistant Evaluation Survey (We conduct our own survey at the end of term to receive feedback about students' learning experience in the course. This evaluation is not associated with the course evaluation administered by the Faculty of Arts and Science.)	1%

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Important course policies and procedures (*please read these carefully!*)

1. Your quiz, assignment, and test grades for BIO120 will be visible to you on Quercus. **It is your responsibility to check your grades** and report any inconsistencies to the BIO120 Office as soon as possible.
2. It is also your responsibility to check your U of T email account on a frequent basis, as any urgent communications will be sent that way. Failure to see an email will not be accepted as an excuse.
3. Please send all course-related email to bio120@utoronto.ca; your email will be forwarded to the appropriate team member. Include your full name and student number in the body of the message. You should use your U of T email address or your emails are likely to be diverted to Junk Mail.
4. You must obtain a minimum average of 50% on the laboratory material (see page *v* in the lab manual) to pass the course. If you do not receive a minimum average of 50% on the laboratory material, the highest possible final grade you can receive is 49% for the course.
5. All tests will be completed online via Quercus, and all assignments will be submitted to Quercus. **If you experience technical issues that affect your ability to complete a test or submit an assignment on time, you must contact bio120@utoronto.ca before the test or assignment deadline**. Technical issues reported after the deadline has passed may not be accommodated.
6. If you **miss Test 1, Test 2, or Test 3** you must contact the BIO120 Office **within 24 hours** of the missed test to receive accommodation. Medical documentation is not required for absences due to illness. The make-up tests include short-answer and multiple-choice questions.
7. **Test conflict with a scheduled class**: If you have a scheduled class at a time when Test 1 and/or Test 2 is being written, *your class* takes precedence (i.e., attend your class and write the make-up test for BIO120). Contact the BIO120 Office no later than *one week* prior to the test date to arrange to write the make-up test. If you do not notify the BIO120 Office before this deadline, we may not be able to arrange an alternate sitting of the test for you. Please provide a screenshot of your ACORN timetable as proof of the conflict.
8. If you **miss your scheduled lab period**, contact the BIO120 Office **within three days** of the missed lab to find out if space is available to attend another lab during the two-week period that each lab is offered. If it is not possible for you to attend a make-up lab, you may be assigned a make-up assignment if you miss an in-lab assignment. The due date and time of lab quizzes do not change, regardless of whether you miss a lab or attend a make-up lab. It is important to note that you can request a make up **for one missed lab** without documentation. If you miss multiple labs due to serious illness or extenuating circumstances, please contact the BIO120 Office to discuss further accommodations. **Note that you are responsible for submitting any assignments that are due for the lab you missed; no extensions will be granted for assignments on or after their due date.**
9. Online labs begin at 1:30 p.m. on Tuesdays, Wednesdays, and Thursdays; at 11:10 a.m. on Fridays; and at 6:10 p.m. on Thursday evenings. Your TA will take attendance at the beginning of each lab. If you arrive late to lab, please alert your TA so that they can record your attendance for the lab.
10. The lab quizzes are completed on Quercus. They are available for seven days preceding the start of lab. Lab quizzes are due by the start date and time of the associated lab. No extensions or exemptions are allowed. Detailed information on the quizzes is available on Quercus.
11. The University of Toronto is committed to accessibility. **If you require accommodations** for a disability, or have any accessibility concerns about the course, the classroom or course materials, contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca *or* https://www.studentlife.utoronto.ca/as.
12. Read page *vi* of the Introduction chapter of the BIO120 Laboratory Manual for **important policies for the lab assignments, including the "Writing a Scientific Proposal" assignment**.

13. **Plagiarism Detection Tool**: Students will submit their "Writing a Scientific Proposal" report (Chapter 6 in the BIO120 Laboratory Manual) to a plagiarism detection tool. Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (*https://uoft.me/pdt-faq*). You can choose to not submit your report to the plagiarism detection tool; please contact the Course Coordinator before Tuesday, Oct. 19th to make alternate arrangements.
14. BIO120 has a zero tolerance policy for **plagiarism**. If you are caught plagiarizing the work of others in any of your assignments, you will receive a grade of zero for the assignment and the office of Student Academic Integrity will be notified.

Schedule for Lectures, Tutorials, Labs, and Tests

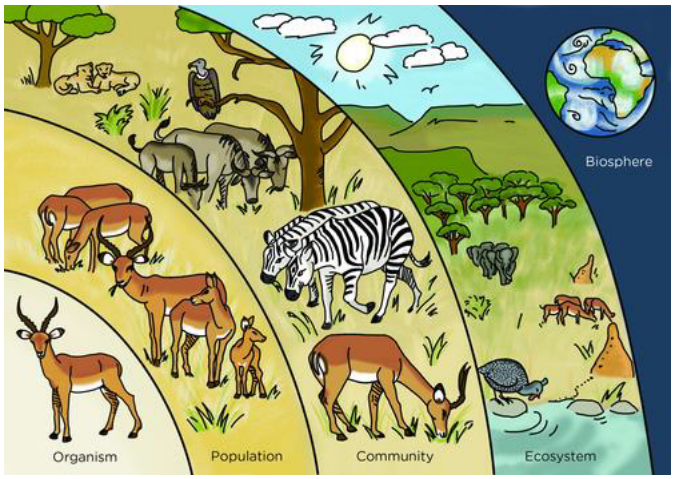
Week	Date	Labs	Lectures	Tutorial Tuesdays 5:10-6 pm	Tutorial Wednesdays 10:10-11 am
1	Sept 9-10	No labs	No lectures or tutorials		
2	Sept 13-17	No labs	1 + 2 (MF)	yes	yes
3	Sept 20-24	1-1*	3 + 4 (MF)	yes	yes
4	Sept 27-Oct 1	1-2	5 + 6 (MF)	yes	yes
5	Oct 4-8	2-1	7 + 8 (MF)	yes	yes
6	Oct 11-15	2-2	9 + 10 (MF)	yes	yes
			Test 1 Wed Oct 13 at 6:30pm Lectures 1-8		
7	Oct 18-22	3-1	11 + 12 (MF)	yes	yes
8	Oct 25-29	3-2	13 + 14 (JS)	yes	yes
9	Nov 1-5	4-1	15 + 16 (JS)	yes	yes
10	Nov 8-12	No labs	Fall Reading Week – no classes		
11	Nov 15-19	4-2	17 + 18 (JS)	yes	yes
			Test 2 Wed Nov 17 at 6:30pm Lectures 9-16, Labs 1-3		
12	Nov 22-26	5-1	19 + 20 (JS)	yes	yes
13	Nov 29-Dec 3	5-2	21 + 22 (JS)	yes	yes
14	Dec 6-9	No labs	23 + 24 (JS)	yes	yes
Faculty End of Term Assessment Period (Dec 10-21): **Test 3 on Lectures 17-24, Labs 4+5+Appendix A**					

* 1-1 = Lab 1, Week 1
1-2 = Lab 1, Week 2
MF = Prof. Megan Frederickson
JS = Prof. John Stinchcombe

ECOLOGICAL BIOLOGY

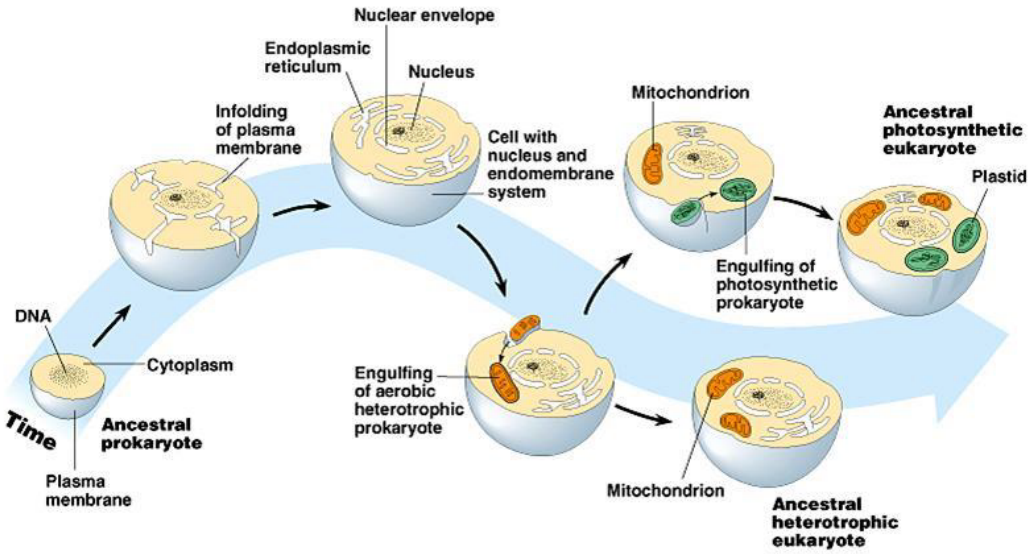
ECOLOGY

- Ecology is the nature of adaptation and the limits to biodiversity.
    - Biodiversity is limited by how organism interact with each other and with the environment.
- Ecology is the study of:
    - Interactions between organisms and their environment.
    - Distribution and abundance of species.
    - Structure and function of ecosystems.
- Ecology focus on:
    - A **population** is all the individuals of the same species in one place at one time.
    - An ecological **community** is all the species living together in one place at one time.
    - An **ecosystem** is all the species + the non-living environment.



SPEICES INTERACTIONS

- **Lynn Margulis** – endosymbiotic theory.

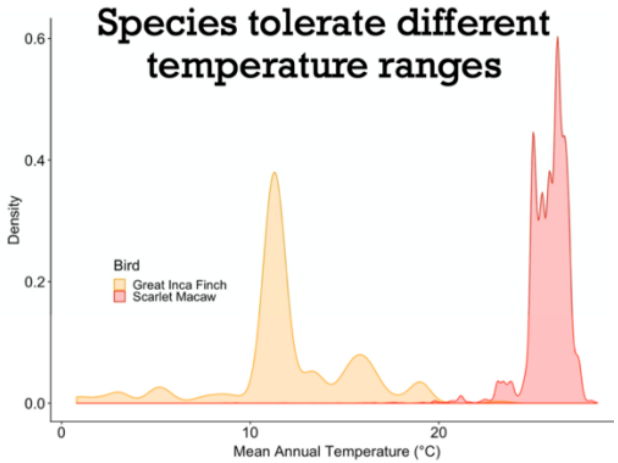


    - Explains the origin of eukaryotic cells from prokaryotic organism.

- States that organelles distinguishing eukaryote cells evolved through **symbiosis** of individual single-celled prokaryotes (mitochondria, chloroplast).
- "Life did not take over the globe by combat, but by networking" - There is more species cooperation than competition than you would think.

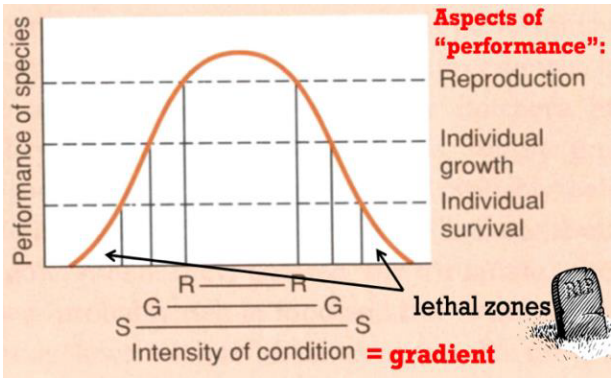
SPECIES DISTRIBUTION

- Determine species range by surveying or collecting them (i.e. eBird).
- Limiting factors that determine species range:
  - **Biotic factors** (organism related):
    - Dispersal.
    - Species interactions: E.g. Competition, predation, mutualism.
  - **Abiotic factors** (organism non-related):
    - Resources: exhaustible (things can be used up): E.g. Nutrients, space, etc.
    - Conditions: inexhaustible (things do not get used up).
      - Usually, gradient formed by variation in condition.
      - E.g. Temperature, salinity, etc.
- Organisms perform best at certain portions of a gradient.



RANGE OF TOLERANCE (ROT)

- Species have ranges of tolerance along environmental gradients.
- Four different ranges of tolerance:
  - Range where the species is able to grow and reproduce.
  - Range where the species can grow and survive but not reproduce.
  - Range where the species can do the minimum to survive and not grow.
  - Range where the species cannot survive.



SPECIES ABUNDANCE

- Species can be abundant or rare at different spatial scales.
  - A locally abundant species may be globally rare, or vice versa.

- The distribution and abundance of species is not static at temporal scale.
    - >99% of species that have ever lived have gone extinct.
    - Ecological succession and extensive shifts in population sizes and ranges due to human activities.
    - Seasonal changes in abundance or range (E.g. migration).
    - Population growth or decline.
- Determine by measuring the number of individuals found per sample.
    - **Relative species abundance** = the ratio of abundance of one species to other species living in an ecosystem.

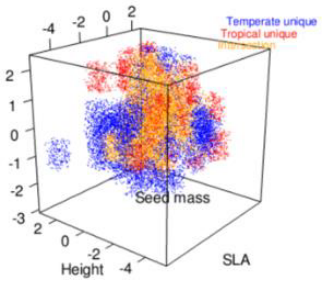
Species distributions are limited in part by resources and conditions. What is the main distinction between these two classes of factors?

a. Resources are biotic, conditions are abiotic.
b. Resources related to temperature, and conditions related to moisture.
c. Resources can be exhausted, and conditions are inexhaustible.
d. Organisms can generally tolerate a wide range of conditions, but only a narrow range of resources

NICHE AXES

ECOLOGICAL NICHE

- The combination of physiological tolerances and resource requirements of a species.
    - A species' place in the world – what climate it prefers, what it eats, etc.
- The Hutchinsonian niche
    - The niche is "an n-dimensional hypervolume" in which each axis is an "ecological factor" important to the species being considered.



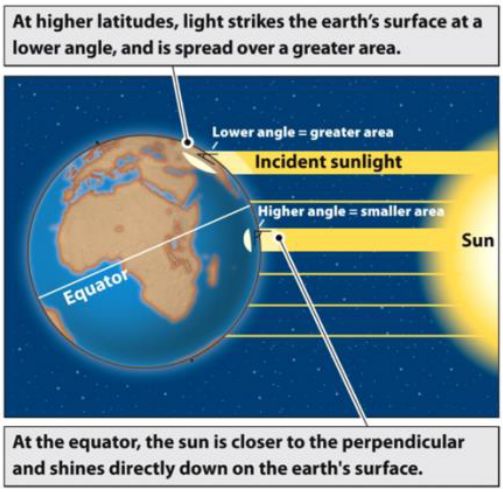
CLIMATIC VARIABLES

- Weather is day to day variation in environmental variables including temperature, precipitation, wind, cloud cover.
    - **Climate** = the long-term average weather.
- Climate varies across the globe.
    - Latitude affects different temperature.
        - **Higher latitude** → colder.
            - Seasonality a function of temperature (warm summer, cold winter).
        - **Lower latitudes** → warmer.

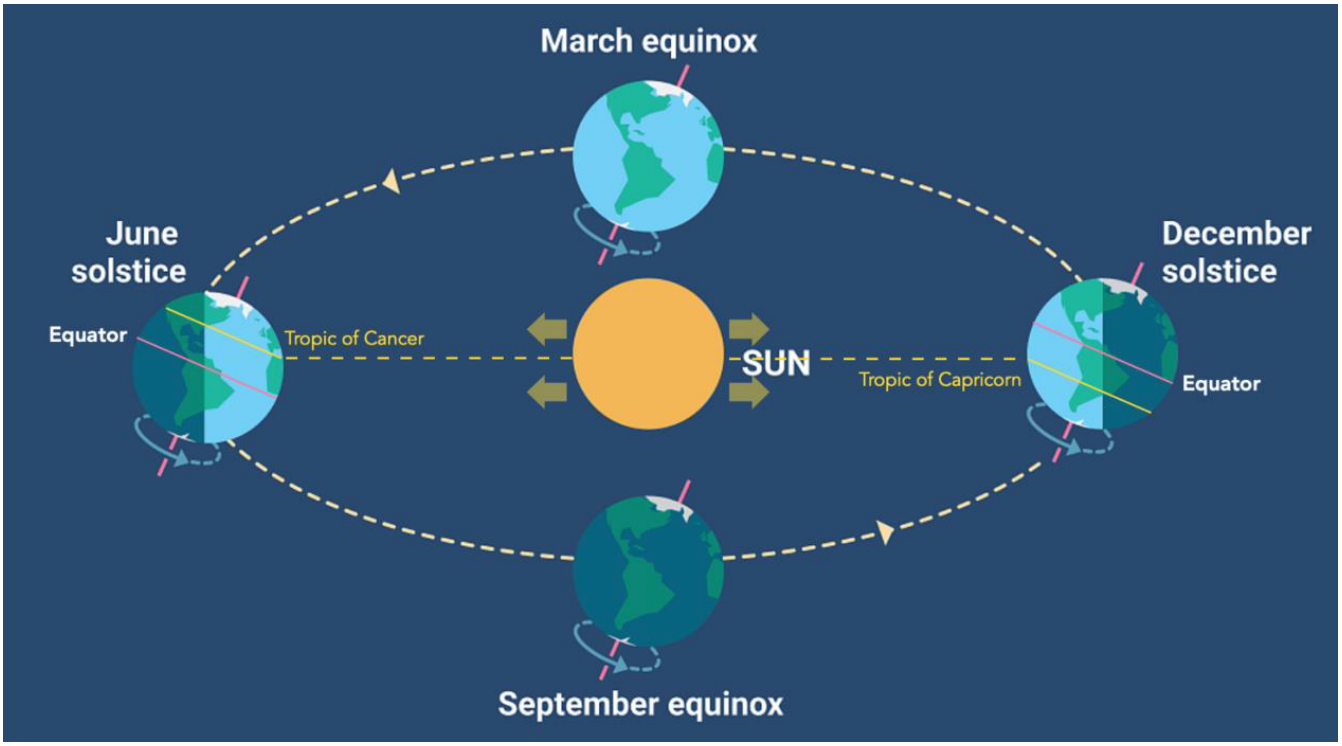
- Seasonality a function of rainfall (dry season, wet season).
- Rainfall mostly depends on atmospheric circulation, ocean currents, rain shadows.

  - These factors determine biomes.

GEOGRAPHY OF EARTH

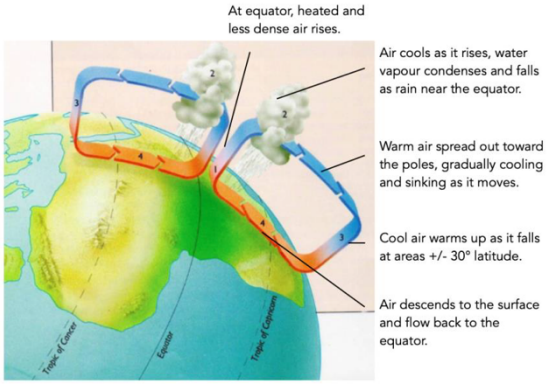


- Effect of a spherical Earth → Latitudinal variation in light energy.
- The Earth is tilted 23.5° → Angle of incoming sunlight is different at different latitude.
  - **Higher latitudes**: light strikes at an angle, energy spread over a wide area.
  - **At solar equator**: light strikes directly down, energy spread over a narrow area.
- Different amount of sunlight produces different temperature and thus seasons.
- **Solar equator** = Latitude closest to the sun.
- Solar equator moves between 23° North (Tropic of Cancer) and 23o South (Tropic of Capricorn).



ATMOSPHERIC CIRCULATION

- Consistent pattern of air movement around Earth's atmosphere.
- Caused by:
  - Sun heats the Earth more at the equator than at the poles.
  - Earth's spin.
  - Uneven distribution of the ocean and continents.



Hadley cells

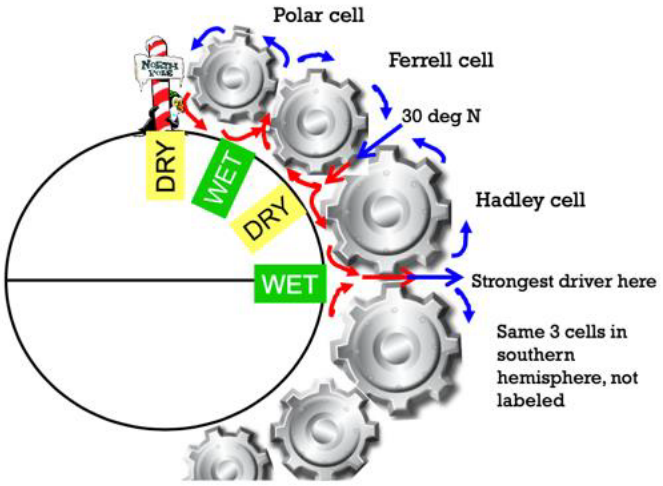
- Largest cells.
- Warm air rises at equator and cool air descends at +/- 30° latitude.

Ferrell cells

- Air rises at +/- 60° latitude and descends at +/- 30° latitude.

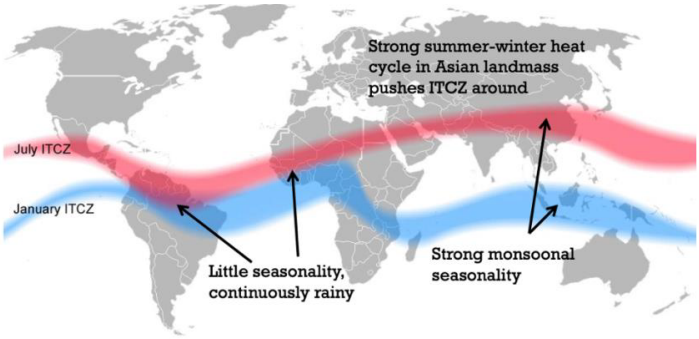
Polar cells

- Smallest cells.
- Cold dense air descends at the pole and warm air rises at +/- 60° latitude.



INTERTROPICAL CONVERGENCE ZONE (ITCZ)

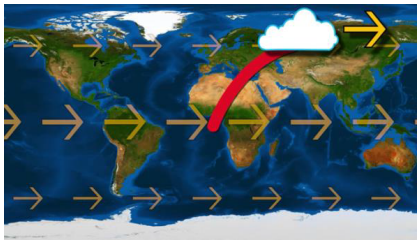
- ITCZ = a narrow zone near the equator where two Hadley cells converge.
  - Area gets heated up by the sun and air is always moving up rains a lot, and low atmospheric pressure.
  - ITCZ moves north and south throughout the year following the solar equator.

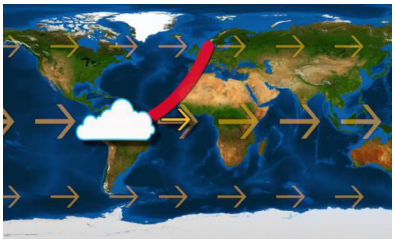


- Areas where ITCZ shifts seasonally → Producing rainy and dry seasons (strong **monsoonal seasonality**).
- Areas where ITCZ does NOT change much → Rainy all year round.

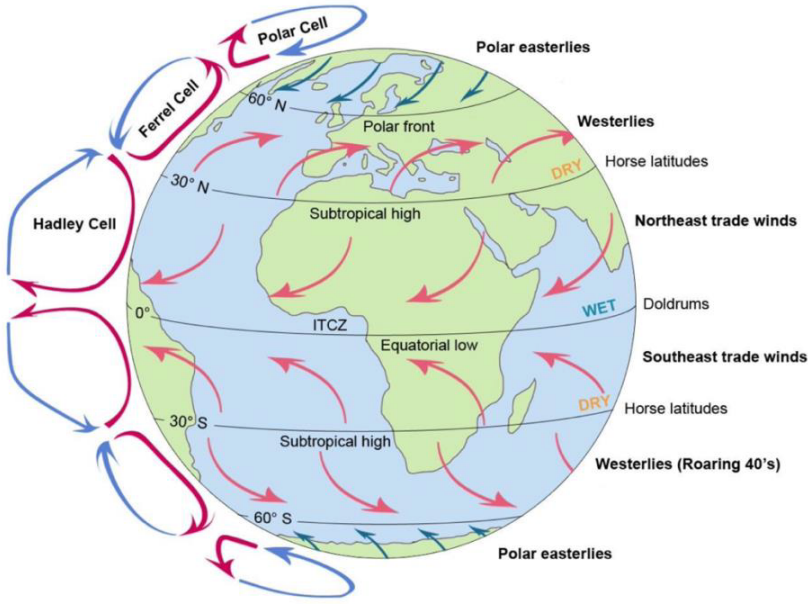
PREVAILING WIND PATTERN

- Coriolis Effect:
  - Earth's surface rotates faster at the equator than at the poles.
  - Air moves away or into the equator will appears in a slightly curved direction (deflection).
  - Only happens in objects in motion.





- **Coriolis effect + Atmospheric circulation cells = Prevailing wind pattern**.
  - When air flowing southwards towards equator → Air deflected to the west.
    - + Hadley cells =
      - **Northeast trade winds** in Northern Hemisphere.
      - **Southeast trade winds** in Southern Hemisphere.
    - + Polar cells =
      - **Polar easterlies.**
  - When air flowing northward towards the poles → Air deflected to the east.
    - + Ferrell cells =
      - **Westerlies.**



- The "roaring forties" – 40°-50° S latitude southern westerlies.
    - Strong <u>westerly</u> wind because there is only ocean and barely any land or mountain to block off the wind.
    - **Wandering albatross** (Diomedea exsulans)
        - Largest wingspan (3.5m).
        - Able to lock shoulder joints and "glide" without flapping their wings (energy efficient).
        - Able to travel very long distances (10 days, 3600 km).
        - Global circumnavigator.
        - Fly <u>north in anticlockwise</u> loops, and <u>south in clockwise loops</u> → Taking advantage of prevailing winds. Adapted to the "roaring forties".

The Intertropical Convergence Zone never passes over some points on Earth's surface. At some points, it arrives once per year, and at other points it passes over twice per year, which results in more complex patterns of wet and dry seasons. On an idealized version of Earth in which land and water were distributed homogeneously, which of the following would BEST describe the place or places at which the ITCZ would arrive only once per year?

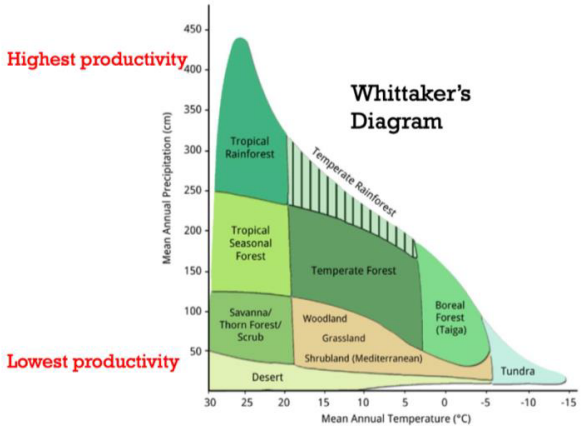
a. The equator, 0 degrees latitude
b. 23.5 degrees N and S latitude
c. The roaring 40s
d. 30 degrees N and S latitude

Major ocean currents circulate clockwise in the northern hemisphere but counter-clockwise in the southern hemisphere. Why?

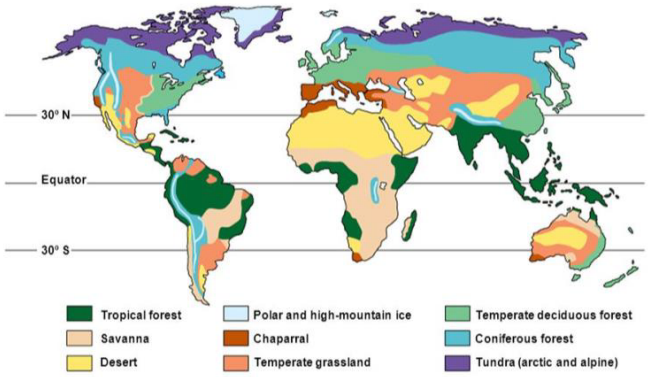
a. Because of Hadley, Ferrell, and polar cells
b. Because of the Coriolis effect
c. Because of the Intertropical Convergence Zone
d. Because of where mountains lie on nearby land masses

BIOME

- Different combinations of climatic variables produce predictable characteristic types of terrestrial vegetation, which is called **biomes**.
- Vegetation growth (primary productivity) and stature increases with moisture (precipitation) and temperature.
    - Seasonality is secondarily important.

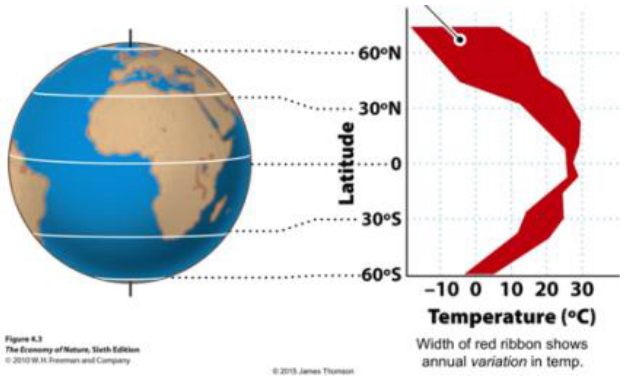


- Latitude mostly determines terrestrial biome.
    - Low pressure area is created where air is rising (around equator, +/- 60°) → More rainfall.
        - Rainforest.
    - High pressure area is formed where air is descending (+/- 30, the poles) → Dry and clear sky.
        - Desert.



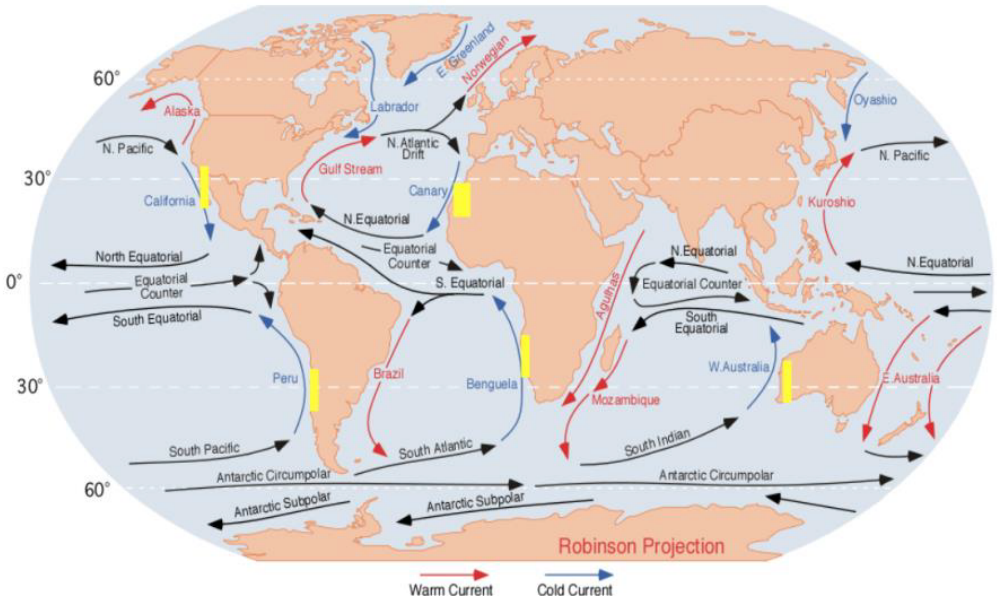
SOURCES OF CLIMATIC VARIATION BEYOND BASIC LATITUDINAL BELTS

- Temperature:
    - Land changes temperature faster than water.
        - Maritime climates are moderate, continental climates are extreme.
        - Oceans provide thermal inertia.
        - Temperatures vary more in the Northern Hemisphere where more land and less water are found.

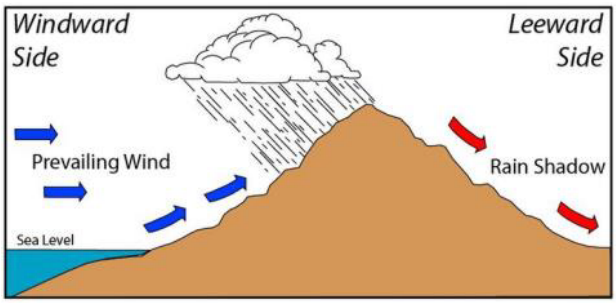


- Precipitation:
    - Evaporation high from warm bodies of water, low from cold bodies of water.

- E.g. Driest deserts are formed at 30° latitude, east of cold ocean current.



- Condense in prevailing winds.
  - **Orographic precipitation** = air forced up mountainsides undergoes cooling, precipitates on upper windward slopes.
  - **Rain shadows** created on leeward slopes of mountain ranges (no rain).
- Seasonality of moisture also important.



With some breaks, mountain ranges run from western North America down through Central America. In North America, specifically Washington, Oregon, and British Columbia, the eastern slope of the Sierra Nevada is drier than the western slope, but in the Talamancas of Costa Rica, this pattern is reversed so the western slope is drier. Which of the following is the most important direct cause of this difference?

a. The intertropical convergence zone passes over Central America but not North America.
b. Because Central America is a narrow isthmus, it has a maritime climate rather than a continental climate.
c. The prevailing winds blow from different directions in the two places.
d. Central America has a monsoonal climate while North America has a temperate climate. e. The Intertropical convergence zone does not pass over Central America, but just reaches it and then retreats toward the equator.

ECOLOGICAL NICHE MODELING

- Range of tolerance ultimately limit distribution.
  - Organisms reactions occur best at optimum conditions and resources, where fitness is maximized.
  - Many mechanisms for homeostasis have evolved to challenge hostile environments.
  - Maintenance of homeostasis requires energy and is often limited by constraints and trade-offs.
- **Geographical range limits**
  - Animals' geographical ranges often correspond to biomes (limited by climate or vegetation).
  - Exceptions:

1. **Interaction with other organisms** (enemies, friends)
   - E.g. Coyote (Canis latrans) habitat range was limited by their enemies wolves (wolves are now mostly killed by human).
2. **Transcend biomes** (ecological versatility, super generalists)
   - E.g. Tiger (Panthera tigris) has broad temperature tolerance, broad habitat range.
3. **Dispersal**
   - Species that have not reached their limits yet due to recent history.

- Ecological niche modelling (species distribution modelling):
  - Uses data from a species' present distribution to predict where a species can live.
  - Assume: species' geographic range is within the species' range of tolerance.
  - Useful for modelling:
    - Biological invasions.
    - How species' ranges may shift as climate changes.
    - Spread of vector-borne diseases, etc.
  - Usually relies on climate data (more rarely on other niche axes).

RANGE SHIFT OF MALARIA DISTRIBUTION IN SOUTH AMERICA

- Predicted range shift
  - Climate change (global warming) influence Plasmodium falciparum (parasite that causes malaria) and Anopheles mosquitoes (vector) distribution in S. America.
- Observed range shifts
  - Species are moving polewards at a fast rate.
  - Due to many factors, but mostly climate change.